

## CLAIMS

I claim:

- 5 1. In a packet switched computer network, a method of estimating periodic worst-case delay for a traffic aggregate having an associated rate, the method comprising:
  - collecting traffic data at a queue associated with the traffic aggregate over a time interval;
  - calculating a traffic profile responsive to the collected traffic data and the associated
  - 10 rate;
  - calculating a periodic worst-case delay for the traffic profile.
2. A method as in claim 1 wherein the traffic data includes packet size and arrival time of each packet arriving at the queue during the time interval.
- 15 3. A method as in claim 2 wherein calculating the profile includes calculating a value of a burst parameter given the associated rate.
4. A method as in claim 3 wherein the associated rate is a negotiated rate agreed to by a
- 20 customer sending the traffic data.
5. A method as in claim 4 wherein the profile is a burst-rate profile.

6. A method as in claim 5 wherein the periodic worst-case delay is calculated by dividing the burst parameter by a allocated bandwidth associated with the queue.

7. A method as in claim 1 wherein the queue is allotted a share of an output link capacity,  
5 said share exceeding the associated rate.

8. A method as in claim 1 wherein the traffic aggregate is a class of traffic.

9. In a packet switched network, a method of estimating worst-case queuing delay along a  
10 path, said path comprising routers, the method comprising:

periodically collecting traffic parameters associated with a queue for each of a plurality  
of routers;

calculating a periodic worst-case delay associated with the traffic parameters for said  
each of a plurality of routers; and

15 adding up the delay associated with the routers along the path.

10. A method as in claim 9 wherein the traffic parameters include a burst parameter and a rate  
parameter.

20 11. In a packet switched network, a method of estimating periodic worst-case queuing delay  
for a class of traffic at a router, the class of traffic having a negotiated rate, the method  
comprising:

receiving packets at an input interface;

sending each packet to one of a plurality of streams responsive to a customer identification;

sending each packet in at least one of the plurality of streams to one of a plurality of queues responsive to a class field;

5 monitoring an arrival time and size of said each packet at the one of the plurality of queues during an interval of time;

calculating a traffic profile responsive to the arrival time and size of said each packet and the negotiated rate; and

calculating a periodic worst-case delay for the traffic profile.

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11. A method for calculating periodic worst-case queuing delay associated with a hypothetical link bandwidth allocation and a set of traffic data, comprising:

calculating a burst parameter given the hypothetical link bandwidth allocation;

determining a periodic worst-case delay for a traffic profile associated with the burst

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parameter and the hypothetical link bandwidth allocation.

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12. A method for calculating worst-case queuing delay associated with a bandwidth and a set of traffic data, comprising:

calculating a burst parameter responsive to the bandwidth and the set of traffic data;

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determining a periodic worst-case delay for a traffic profile associated with the burst parameter and the link bandwidth.

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13. In a packet switched network, an apparatus for estimating worst-case delay for a traffic aggregate having an associated rate, the apparatus comprising:

a monitor that collects traffic data at a queue associated with the traffic aggregate over a time interval;

a processor; and

a computer readable medium coupled to the processor and storing a computer program

5 comprising:

code that causes the processor to receive the traffic data;

code that causes the processor to calculate a traffic profile responsive to the collected traffic data and the associated rate; and

code that causes the processor to calculate a periodic worst-case delay for the

10 traffic profile.

<sup>15</sup>  
~~14.~~ An apparatus as in claim 13 wherein the traffic data includes packet size and arrival time of each packet arriving at the queue during the time interval.

<sup>16</sup>  
15 ~~15.~~ An apparatus as in claim 13 wherein calculating the profile includes calculating a burst parameter.

<sup>17</sup>  
~~16.~~ An apparatus as in claim 13 the profile is a burst-rate profile.

<sup>18</sup>  
20 ~~17.~~ An apparatus as in claim 13 wherein the periodic worst-case delay is calculated by dividing the burst parameter by a allocated bandwidth of the queue.

<sup>19</sup>  
~~18.~~ The system of claim 13, wherein the computer readable medium is a CD-ROM, floppy disk, flash memory, system memory, hard drive, or data signal embodied in a carrier wave.

19. In a packet switched network, an apparatus for estimating periodic worst-case queuing delay along a path, said path comprising routers, the apparatus comprising:

a monitor agent that periodically collects traffic parameters associated with a queue for

5 each of a plurality of routers;

a processor that can receive information from the monitor agent; and

a computer readable medium coupled to the processor and storing a computer program comprising:

code that causes the processor to receive traffic parameters collected by the

10 monitor agent;

code that causes the processor to calculate a delay associated with the traffic parameters for said each of a plurality of routers; and

code that causes the processor to add up the delay associated with the routers along the path.

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20. An apparatus as in claim 19 wherein the traffic parameters include a burst parameter and a rate parameter.

21. The apparatus of claim 19, wherein the computer readable medium is a CD-ROM, floppy disk, flash memory, system memory, hard drive, or data signal embodied in a carrier wave.

22. In a packet switched network, an apparatus for estimating periodic worst-case delay for a traffic aggregate having an associated rate, the apparatus comprising:

means for collecting traffic data at a queue associated with the traffic aggregate over a time interval;

means for calculating a traffic profile responsive to the collected traffic data and the associated rate; and

5 means for calculating a periodic worst-case delay for the traffic profile.

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23. An apparatus as in claim 22 wherein the traffic data includes packet size and arrival time of each packet arriving at the queue during the time interval.

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10 24. In a packet switched network, an apparatus for estimating periodic worst-case queuing delay along a path, said path comprising routers, the apparatus comprising:

means for periodically collecting traffic parameters associated with a queue for each of a plurality of routers;

means for calculating a delay associated with the traffic parameters for said each of a plurality of routers; and

15 means for adding up the delay associated with the routers along the path.

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25. An apparatus as in claim 24 wherein the traffic parameters include a burst parameter and a rate parameter.

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20 26. A computer program product for estimating periodic worst-case delay at a queue in a packet switched network, the computer program product comprising:

computer code that causes a processor to collect traffic data at the queue over a time interval, said traffic data having an associated negotiated rate;

computer code that causes a processor to calculate a traffic profile responsive to the collected traffic data and the associated negotiated rate;

computer code that causes a processor to calculate a periodic worst-case delay for the traffic profile and a allocated bandwidth associated with the queue; and

5 a computer readable medium storing said computer code.

<sup>26</sup>  
27. A computer program product as in claim 25 wherein the traffic data includes packet size and arrival time of each packet arriving at the queue during the time interval.

<sup>29</sup>  
10 28. A computer program product for estimating worst-case queuing delay along a path in a packet switched network, said path comprising routers, the computer program product comprising:

computer code that causes a processor to collect traffic parameters associated with a queue for each of a plurality of routers;

<sup>30</sup>  
15 computer code that causes the processor to calculate a delay associated with the traffic parameters for said each of a plurality of routers; and

computer code that causes the processor to add up the delay associated with the routers along the path; and

a computer readable storage medium storing said code.

<sup>31</sup>  
20 29. An apparatus as in claim 28 wherein the traffic parameters include a burst parameter and a rate parameter.

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30. In a packet switched network, a method of estimating worst-case queuing delay along a path, said path comprising routers, the method comprising:

calculating periodic worst-case delay associated with a queue for each of a plurality of routers;

5 periodically collecting periodic worst-case delay from said each of a plurality of routers; and

adding up the delay associated with the routers along the path.

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31. A method as in claim 30 wherein the traffic parameters include a burst parameter and a

10 rate parameter.